THE BIOMASS POTENTIAL OF EXISTING LINEAR WOODY-FEATURES IN THE AGRICULTURAL LANDSCAPE

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Abstract

Linear woody-features, such as hedgerows, windbreaks, and riparian buffer strips, composed of trees and/or shrubs are anthropogenic features, established in the past for different purposes, such as provision of field boundaries, protection from wind and supply of fuelwood. Today, they are primarily valued for their ecological benefit, while their production function has received rather little attention. This study assessed the biomass potential of existing linear woody-features in a study area in southern Brandenburg, Germany. The merchantable tree volume of the measured woody-features ranged between 240 m^3 ha^{-1} and 710 m^3 ha^{-1}, depending on the relative proportion of trees and shrubs. The results suggest that the biomass potential of linear woody-features with predominant tree proportion per hectare can be higher than this of forests. A strategy for utilising the production function of these woody-features should take into account the provision of benefits such as wind protection, habitat provision and landscape aesthetics.

Keywords: hedgerows; merchantable tree volume; production function; utilization strategy

Introduction

Linear woody-features, such as hedgerows, windbreaks, and riparian buffer strips, composed of trees and/or shrubs are anthropogenic features, established in the past within agricultural landscapes for different purposes, such as provision of field boundaries, protection from wind, and supply of fuel wood and other products (Baudry et al. 2000). Due to mechanization and intensification of agriculture, in the past, they were perceived as obstacles to agricultural production and have increasingly been removed from the landscape (Nerlich et al. 2013). The ecological benefit of trees outside the forest, including linear woody-features, is more widely recognized in today's' agricultural policy. For example, farmers can register hedges and wooded strips as landscape features which are recognised as Ecological Focus Area (EFA) under Pillar 1 of the Common Agricultural Policy (CAP). In addition, several options in the Rural Development Regulation (Pillar 2) of the CAP support the restoration and maintenance of traditional hedgerow systems or parkland trees. However, within these options there is little emphasis on managing tree-based systems for their productivity. Throughout Europe such semi-natural features of high nature value are threatened by both intensification and land abandonment (Plieninger 2012).

According to Schleyer and Plieninger (2011), among the obstacles for farmers in the German province of Saxony to enter a payment scheme that supports woody-features were high production and opportunity costs for land use, contractual uncertainties and land-tenure implications. Administrative and economic considerations were among the main reasons for the low registration of EFA options such as landscape features and buffers strips in Germany (Zinngrebe et al. 2017). Moreover, farmers in Germany are not allowed to harvest existing linear woody-features, even if they are not financially supported by the CAP, because they stand under protection by local regulations. However, as man-made features, they need to be preserved, managed and maintained continuously for the adequate provision of ecosystem functions and services (Baudry et al. 2000; Schleyer and Plieninger 2011). The aim of this study

was to estimate the biomass potential of existing linear woody-features in the agricultural landscape, not registered for subsidies under the CAP, in order to assess the production function of these features.

Materials and methods

Study area

The study area is located in the southern part of the eastern German province of Brandenburg within the administrative district of Kleine Elster and the municipalities Sonnewalde and Finsterwalde (Figure 1). In 2015, the linear woody-features (not classified as forest area or registered for subsidies under the CAP) adjacent to agricultural landscapes in this area, were digitized based on the crown visible in digital orthophotos (40 cm-resolution) obtained from the Brandenburg Surveying and Geoinformation Office (LGB). These images are also accessible to farmers and form the basis of their annual agricultural declarations. Within the region a 4 km^2 (~1% from the total area) representative study area was selected, which was comparatively rich in linear woody-features. Within this area the woody-features were classified on-site according to their woody vegetation cover (tree cover (0-33%, 33-66%, and 66-100%) and shrub cover (0-33%, 33-66%, and 66-100%)) and their density (closed, with small gaps (1-33% of the woody-feature), with large gaps (>33% of the woody-feature)). From these classes up to three linear woody-features representing each combination were randomly selected for biomass assessment (Figure 1).

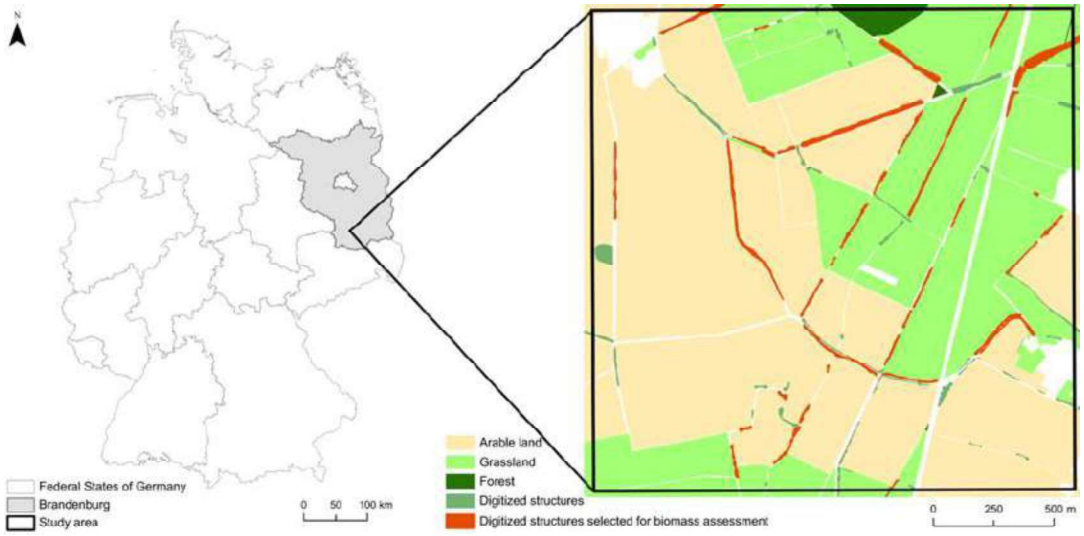

Figure 1: Map of Germany with the study area in the province of Brandenburg, main land use and the digitized linear woody-features, highlighting those randomly selected for biomass assessment (n=37).

Biomass potential

In the selected linear woody-features, measurements of tree height, diameter at breast height (DBH) when it was wider than 7 cm, together with the tree species were recorded. For woody-features longer than 100 m the measurements took place in five plots, each 20 m long, which were equally distributed throughout the total length. For woody-features shorter than 100 m the whole feature was recorded. The measurements were used to determine the theoretical biomass potential, i.e. the maximal biomass potential of these features. The merchantable tree volume (V) in m^3 is the product of tree basal area (g [m^2]), tree height (h [m]) and a form factor (f) that converts total tree volume to merchantable tree volume (Kramer and Akça 2008):

$$V = g \times h \times f \qquad [1]$$

$$g = \frac{\pi}{4} \times DBH^2 \qquad [2]$$

Results and discussion

Linear woody-feature description

The average length of the woody-features was 200 m, while the average width was 5 m. Although the width of the measured woody-features was predominantly below the threshold of 10 m set by Regulation (EU) No 639/2014 for landscape features, such as hedges and wooded strips, they were not registered as such. The distribution of tree species according to their DBH is shown in Figure 2. The most common species were *Alnus glutinosa*, *Populus spp*. and *Quercus robur* composing 52%, 17% and 13% of the tree species recorded, respectively. *Alnus glutinosa* is typically grown along ditches. Accordingly, the highest proportion of the digitized features were riparian buffer strips. The rest of these features could be classified as hedgerows and windbreaks.

In the period between 1950 and 1980 planting fast growing trees such as *Alnus glutinosa* and *Populus* was common in Germany (Reif and Achtziger 2000). The main purpose was protection from wind and erosion as well as production of wood. Non-native hybrid poplar trees were often planted, which were since then neither harvested nor managed and currently these aged trees cause problems in the management of adjacent agricultural areas by breakage of tree branches and logs lying in the fields (DVL 2006). These features were typically monotonous which is consistent with the species recorded within the study area. More than half of the woody-features consisted of one or two tree species amounting to 28% and 39%, respectively. Besides hybrid poplar a non-native species to the area was *Quercus rubra* which however accounted for less than 1% of the tree species.

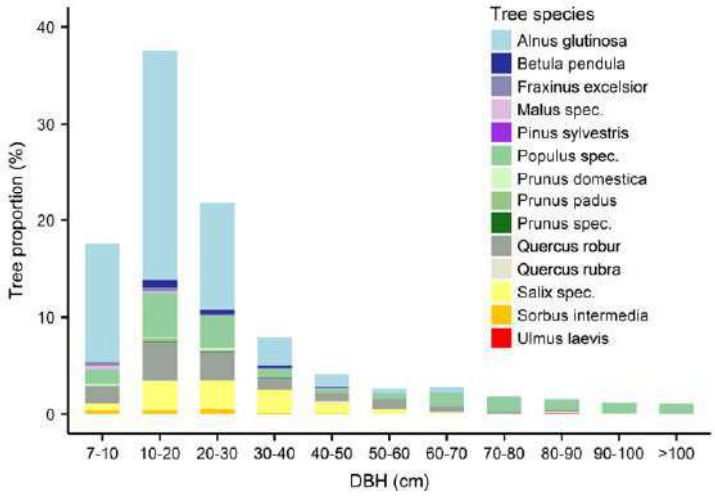

Figure 2: Distribution of tree species according to their diameter at breast height (DBH) measured in cm (n=1277).

Theoretical biomass potential

The area of all digitized linear woody-features amounted to 2.9% of the agricultural area. The mean and standard error of the 37 woody-features ranged between 25±5 cm and 49±16 cm for DBH and between 10±1 m and 18±3 m for height. The form factor was extracted from yield tables for the main tree species in the area (Schober 1995). The calculated mean biomass potential of the linear woody-features according to the proportion of trees and shrubs is presented in Table 1. The merchantable tree volume ranged between 240 m^3 ha^{-1} and 710 m^3 ha^{-1} with weighted average over the area amounting to 540 m^3 ha^{-1}. The calculated potential per hectare woody area was higher than the average stocks of biomass in German forests of 330 m^3 ha^{-1}, reported by the Third National Forest Inventory (TI 2012). The biomass potential of these woody-features was more comparable with the biomass stock of older forest, such as this estimated in the province of Schleswig-Holstein, amounting to 550 m^3 ha^{-1} (TI 2012). The high biomass potential of woody-features with predominately tree proportion could be due to the fact that trees receive more light as compared to forest conditions and can be planted in higher density. The stem number per hectare in the woody-features was up to 1500 stems ha^{-1},

consequently, also higher as compared to forests, where the highest stem number of ~900 stems ha^{-1} was found in Brandenburg. However, it has to be considered that the linear woody-features within the landscape are widely spread and their total area can be comparatively small. In the study area, it amounted to 10.6 ha.

Table 1: Estimated theoretical biomass potential (mean ± SE) of the linear woody-features according to the relative proportion of trees and shrubs (n=37)

Vegetation cover [%]		n	Merchantable tree volume [m^3 ha^{-1}] mean (±SE)	Total area of all woody-features [ha]
Shrubs	Trees			
0-33	0-33	3	250 (±80)	0.3
0-33	33-66	6	430 (±140)	1.6
0-33	66-100	7	690 (±190)	4.3
33-66	0-33	1	350 (NA)	0.2
33-66	33-66	7	310 (±40)	1.0
33-66	66-100	4	710 (±30)	1.2
66-100	0-33	6	240 (±110)	0.7
66-100	33-66	0	NA	0.0
66-100	66-100	3	470 (±80)	1.3

The initial results suggest a high biomass potential of linear woody-features in the agricultural landscape. In addition to production function, the assessment of woody-features should consider ecosystem functions such as wind protection, provision of habitat and landscape aesthetics (Hübner 2016). A management strategy should be developed, considering which species should be primarily harvested, prioritizing non-native species and which species should be used for replanting to enhance the ecological function of existing woody-features, as it was demonstrated by Romer et al. (2016). The management and maintenance of these features for the balanced provision of functions should be considered at the landscape scale. Only a small proportion of the biomass should be harvested annually with the aim of preserving linear woody-features for improved ecosystem functions.

Conclusion

The study estimated the theoretical biomass potential of existing linear woody-features in an agricultural landscape in southern Brandenburg. The initial results suggested that the potential of woody-features with predominating tree proportion per hectare can be higher than this of forests. The area of woody-features is however comparatively small and they can be widely spread in the landscape. Nevertheless, it is necessary to develop a management strategy for using the production function of these features. Moreover, maintaining woody-features through regular harvests, as it was practiced in the past, would improve their condition and enhance the provision of ecosystem functions, such as landscape aesthetics, habitat for biodiversity, and soil protection.

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